PROCEEDINGS
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April 2, 1840.

The MARQUIS of NORTHAMPTON, President, in the Chair.

His Grace the Duke of Richmond and John Gwyn Jefferys, Esq., were balloted for, and duly elected into the Society.

The following papers were read, viz.:

"Additional note to the Eleventh Series of Researches on the Tides." By the Rev. William Whewell, B.D., F.R.S., &c.

As an appendix to his former memoir on tide observations, the author gives in the present paper the results of observations made at Petropaulofsk, in the bay of Avatcha, in Kamtchatka, lat. 53° 1′ N., long. 158° 44′ E., by the officers and men of the Seuivine, commanded by the present Russian Admiral Lütke; and which were conducted with great care and perseverance. The height of the surface was noted every ten minutes, both day and night, and when near its maximum every two minutes.

It appears from these observations that the high water is affected in its time by a very large diurnal inequality, reaching the enormous amount of above four hours; while its height is only slightly affected by an inequality of that kind; the greatest alternate inequalities of height were something more than a foot. In the low waters, there appears a much smaller inequality in the times, seldom amounting to more than one hour; but with regard to height, the diurnal inequality is much larger than that for high water, reaching to three, or even four feet; and this in a tide of which the whole rise, from the lowest to the highest, rarely exceeds five feet. The theory of these phenomena is then discussed.

The results of another series of observations made in July 1827, at the port of Novo-Arkhangelsk, in the island of Sitkhœ, in Norfolk Sound (lat. 57° 2′ N., long. 135° 18′ W.), are also given, and their theory considered.

A paper was also in part read, entitled, "On the Nervous System." By Sir Charles Bell, F.R.S.

April 9, 1840.

The MARQUIS of NORTHAMPTON, President, in the Chair.

John P. Gassiot and Thomas Henderson, Esqrs., were balloted for, and duly elected into the Society.

The reading of a paper, entitled, "On the Nervous System." By Sir Charles Bell, F.R.S., was resumed and concluded.

The author adverting to the papers on the nervous system, which he presented to the Royal Society nearly twenty years ago, recapitulates the train of reasoning which originally led him to the inquiries in which he has been so long engaged, on the different functions of different classes of nerves, and adduces various pathological facts in corroboration of the correctness of the views he then entertained. With regard to the spinal nerves, cases are related where, in consequence of disease of the bodies of the vertebræ, the anterior columns of the spinal cord, and anterior roots of the nerves were affected, and paralysis of the muscles to which those nerves are distributed was produced, while the posterior column of the cord was uninjured, and the sensibility unimpaired. The author next considers the respiratory system of nerves, which he regards as being both muscular and sensitive, and describes as arising from a tract of the spinal cord, on the outside of the *corpus olivare*, and anterior to the *processus ad cerebellum*; and which constitute columns having no decussations with one another, as is the case with the other systems. The conclusion he originally formed, that both the phrenic and the spinal accessory nerves are provided for motion, which he had deduced from the anatomical fact of the former taking a direct course to the diaphragm, and the latter a circuitous one for the purpose of associating the muscles of the respiratory organs with those which act on the chest, is, he thinks, amply confirmed by subsequent experiments. He concludes his paper with some remarks on the supply of blood to the respiratory system of nerves, which supply, being derived from branches of the vertebral arteries, affords an explanation of several pathological phenomena.

A paper was also read, entitled, "On the constitution of the Resins. Part IV." By James F. W. Johnston, Esq., M.A., F.R.S.

This paper contains the account of the continuation of the author's previous researches into the constitution of the resins, both as they occur in nature, and as they appear when extracted from the natural products by the agency of alcohol or ether. The great difficulty in this inquiry is to determine when the resin to be analysed is obtained in its normal state; and the author has endeavoured in each case to ascertain this point by repeated analyses of the resins prepared under different conditions. He thus arrives at the conclusion, that the resin of scammony extracted from crude scammony by alcohol, and heated to 260° Fahr., is represented by $C_{40}\ H_{33}\ O_{20}$, containing the largest amount of oxygen of any resin hitherto analysed. The resin of jalap, obtained by evaporating the alcoholic extract, and afterwards boiling it in water, is represented by $C_{40}\ H_{34}\ O_{18}$, and in the amount of oxygen it contains is only surpassed by the resin of scammony. It is interesting to remark that these two resins in their effects on the animal economy are as nearly related as these formulæ show them to be in chemical constitution.

The resin of labdanum, extracted by alcohol from the crude labdanum and evaporated, gave the formula $C_{40}\ H_{33}\ O_{8}$; but this extract, softened in the air and water, took up from it a bitter substance of a brown colour. After boiling in water, the pure resin is represented by $C_{40}\ H_{33}\ O_{7}$.

The Berengela resin, previously analysed by the author before he was aware of the conditions necessary to be attended to in order to obtain a resin in its normal state, is expressed by the formula $C_{40}\ H_{30}\ O_{7}$; and the resin of Retin asphalt, also previously analysed by the author, by $C_{40}\ H_{27}\ O_{6}$.

The resin of ammonia, extracted by alcohol from the crude gum resin, is represented by $C_{40}\ H_{25}\ O_{9}$; the resin of opoponax by $C_{40}\ H_{25}\ O_{14}$; and that of assafœtida by $C_{40}\ H_{26}\ O_{10}$.

A striking relation appears between the formulæ for the resins of ammonia and assafœtida, the former being $C_{40}\ H_{25}\ O_{9}$, the latter $C_{40}\ H_{26}\ O_{10}$, as if the latter were merely a hydrate of the former. The author considers this relation, and concludes that it is only apparent, and that probably in neither of the resins does any of the hydrogen exist in combination with oxygen in the state of water.

This leads the author to inquire into the general action of a slightly elevated temperature on the resins, and he concludes that in all cases when a resin in its normal state is heated a few degrees above its melting point, it begins to suffer partial decomposition, accompanied by the solution of water, and *always* by more or less of a volatile, generally oily compound, sometimes containing less and sometimes more oxygen than the resin which has been subjected to heat. In the case of some resins, especially such as are agreeably fragrant, and are expressed by the second of the author's general formulæ $C_{40}\ H_{24} \pm x\ O_{7}$, benzoic acid is one of the products of decomposition at a moderate temperature. Thus the resin of dragon's blood gives only a trace of benzoic acid, with water and a red volatile compound; while the resin of benzoin gives much benzoic acid. Some resins give off volatile matters and diminish in weight long before they reach the fusing point; as is the case with the resin of benzoin, of which the melting point is high. With regard to the special action of such temperatures in altering the atomic constitution of the resins, the author finds that each resin undergoes a change, probably peculiar to itself, and probably depending on the nature of the organic radical it contains. Thus, the formula for the resin of retin asphalt $(= C_{40}\ H_{27}\ O_{6})$ by prolonged heating at the melting point becomes $C_{40}\ H_{27}\ O_{5}$. Ammonia resin $(= C_{40}\ H_{25}\ O_{9})$ by heating at 270°

Fahr. *approaches* to $C_{40}\ H_{24}\ O_8$; there being, however, a slight excess of oxygen, and water not being the only volatile compound driven off.

The resin of opoponax, when thus heated the hydrogen, as in that of retin asphalt, remains nearly constant $= C_{40}\ H_{25}\ O_{14}$, approaching to $C_{40}\ H_{25}\ O_{12}$. The same is the case with the resin of assafœtida ($= C_{40}\ H_{26}\ O_{10}$), which by prolonged heating at about 250° Fahr., becomes $C_{40}\ H_{26}\ O_9$. These observations when multiplied are likely to assist materially in leading to *rational* formulæ, expressive of the molecular constitution of the resins.

In reference to the general questions, with a view to the solution of which the author undertook this investigation, he concludes:

1. That the resins are not to be considered as different compounds of one and the same radical, but rather as analogous groups of compounds of analogous radicals.

2. That as far as our present knowledge extends, all the *true* resins are capable of being represented by irrational formulæ, in which C_{40} is a constant quantity.

3. That the analyses contained in the present paper render necessary a slight modification in the general formulæ previously announced. The formula for the group of which colophony is the type, being $C_{40}\ H_{32} \pm x\ Oy$; and that for the group of which gamboge or dragon's blood is the type, being $C_{40}\ H_{24} \pm x\ Oy$.

The author announces a further continuation of these researches, in which the constitution of other resins will be given, and the relations of the resins to certain chemical reagents will be explained and illustrated.

The Society then adjourned over the Easter Recess, to meet again on the 30th instant.

April 30, 1840.

The MARQUIS of NORTHAMPTON, President, in the Chair.

His Royal Highness Prince Albert, of Saxe Coburg and Gotha, K.G., was proposed as a Fellow of the Royal Society by the President, seconded by John W. Lubbock, Esq., V.P. and Treasurer R.S., and, being put to the ballot, H.R.H. was elected a Fellow of the Royal Society.

Lord Lyttleton was also, pursuant to a notice given at the last meeting, put to the ballot, and elected a Fellow of this Society.

Thomas Wharton Jones, Esq., and John Grant Malcolmson, M.D., were also balloted for, and duly elected into the Society.

The following communications were read:—

1. A Letter from Sir John Barrow, Bart., V.P., addressed to the President, accompanying a series of Magnetic Observations made on

shore, and on board Her Majesty's ships 'Erebus' and 'Terror,' under the direction of Captain James Clark Ross, R.N., together with a Series of Observations made on the temperature and specific gravity of the ocean at various depths, and at the surface, namely,

"Observations of the magnetic intensity on shore, and on board H.M.S. Erebus, with needle F. 1.

"Magnetic dip observations on shore, and on board H.M.S. Erebus, with needle F. 1.

"Observations for the magnetic dip on shore, and on board H.M.S. Terror.

"Observations of the magnetic dip by needle F. C. 5. on shore, and on board H.M.S. Terror.

"Observations in magnetic intensity by needle F. C. 5. on shore, and on board H.M.S. Terror."

The whole of these observations are up to the 31st December, 1839. They are transmitted to the Royal Society from the Lords Commissioners of the Admiralty.

2. Postscript to Major Sabine's paper, entitled "Contributions to Terrestrial Magnetism," which was read at the last meeting; containing an extract from a letter from Capt. James Clark Ross, commanding the Antarctic expedition, dated from St. Helena, February 9th, 1840; noticing the success which had attended the employment of Mr. Fox's instrument, in observations of the magnetic dip and intensity on shipboard.

3. "A few remarks on a Rain Table and Map," drawn up by Joseph Atkinson, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The table and map which accompany this paper exhibit the average annual depth of rain falling in different places in Great Britain.

4. "Extracts from a Meteorological Journal kept at Allenheads, in the county of Northumberland," by the Rev. W. Walton, F.R.S.

The general result of these observations, which were recorded twice each day, namely, at 9 A.M., and at 3 P.M., during the whole of the year 1839, is, that the mean temperature taken at those times was 44° 8′; the mean height of the barometer, corrected and reduced to the temperature of 32°, was 28·401 inches, and the quantity of rain in the year was 55·71 inches. The author subjoins several remarks on the conclusions deducible from an examination of the tables.

5. "Description of an Astronomical Clock invented by the late Captain Henry Kater, F.R.S.," drawn up from his own memorandums by his son Edward Kater, Esq. Communicated by Sir John F. W. Herschel, Bart., V.P.R.S.

The great object aimed at by Captain Kater in the construction of the escapement of a chronometer, is to communicate equal impulses to the pendulum through some principle perfect in itself, and not dependent for its success on superior execution. In the escapement invented by him, the pendulum merely raises a weight, and is impelled by that weight through an increased space in its descent. It neither unlocks a detent, nor has anything to do with the train; and as the weight raised, and the spaces described, are constant quantities, this escapement is, in the strict meaning of the term, one of equal impulse.

May 7, 1840.

JOHN WM. LUBBOCK, Esq., M.A., V.P. and Treasurer, in the Chair.

John Auldjo, Esq., and William Sharp, Esq, were balloted for, and duly elected into the Society.

A paper was read, entitled "Researches in Embryology, Third Series: a Contribution to the Physiology of Cells." By Martin Barry, M.D., F.R.S., F.R.S.E., Fellow of the Royal College of Physicians in Edinburgh.

In the second series of these researches, the author had traced certain changes in the mammiferous ovum consequent on fecundation. The object of his present communication is to describe their further appearances obtained by the application of higher magnifying powers; and to make known a remarkable process of development thus discovered. In order to obtain more exact results, his observations were still made on the same animal as before, namely, the rabbit, in the expectation that, if his labours were successful, it would be comparatively easy to trace the changes in other mammals. By pursuing the method of obtaining and preserving ova from the Fallopian tube which he recommended in his last paper, he has been enabled to find and examine 137 more of these delicate objects; and has thus had ample opportunity of confirming the principal facts therein stated. He has now procured in all 230 ova from the Fallopian tube. But being aware that repeated observations alone do not suffice in researches of this nature, unless extended to the very earliest stages, he again specially directed his attention to the ovum while it is still within the ovary, with a view to discover its state at the moment of fecundation, as well as immediately before and after that event.

The almost universal supposition, that the Purkinjian or germinal vesicle is the essential portion of the ovum, has been realized in these investigations; but in a manner not anticipated by any of the numerous conjectures which have been published. The germinal vesicle becomes filled with cells, and these again become filled with the foundations of other cells; so that the vesicle is thus rendered almost opake. The mode in which this change takes place is the following, and it is one which, if confirmed by future observation, must modify the views recently advanced on the mode of origin, the nature, the properties, and the destination of the nucleus in the physiology of cells. It is known that the germinal spot presents, in some instances, a dark point in its centre. The author finds that such a point is invariably present at a certain period; that it enlarges, and is then found to contain a cavity filled with fluid, which is exceedingly pellucid. The outer portion of the spot resolves itself into cells; and the foundations of other cells come into view in its interior, arranged in layers around the central cavity; the outer layers being pushed forth by the continual origin of new cells in the interior. The latter commence as dark globules in the pellucid fluid of the central cavity. Every other nucleus met with in these researches has seemed to be the seat of changes essentially the same. The appearance of the central portion of the nucleus is, from the above process, continually varying; and the author believes that the nature of the nucleolus of Schleiden is to be thus explained. The germinal vesicle, enlarged and flattened, becomes filled with the objects arising from the changes in its spot; and the interior of each of the objects filling it, into which the eye can penetrate, presents a repetition of the process above described. The central portion of the altered spot, with its pellucid cavity, remains at that part of the germinal vesicle which is directed towards the surface of the ovum, and towards the surface of the ovary. At the corresponding part, the thick transparent membrane of the ovum in some instances appears to have become attenuated, in others also cleft. Subsequently, the central portion of the altered spot passes to the centre of the germinal vesicle; the germinal vesicle, regaining its spherical form, returns to the centre of the ovum, and a fissure in the thick transparent membrane is no longer seen. From these successive changes it may be inferred that fecundation has taken place; and this by the introduction of some substance into the germinal vesicle from the exterior of the ovary. It may also be inferred, that the central portion of the altered germinal spot is the point of fecundation. In further proof that such really is the case, there arise at this part two cells, which constitute the foundation of the new being. These two cells enlarge, and imbibe the fluid of those around them, which are at first pushed further out by the two central cells, and subsequently disappear by liquefaction. The contents of the germinal vesicle thus enter into the formation of two cells. The membrane of the germinal vesicle then disappears by liquefaction.

Each of the succeeding twin cells presents a nucleus, which, having first passed to the centre of its cell, resolves itself into cells in the manner above described. By this means the twin cells, in their turn, become filled with other cells. Only two of these in each twin cell being destined to continue, the others, as well as the membrane of each parent-cell, disappear by liquefaction, when four cells remain. These four produce eight, and so on, until the germ consists of a mulberry-like object, the cells of which do not admit of being counted. Nor does the mode of propagation continue the same with reference to number only. The process inherited from the germinal vesicle by its twin offspring, reappears in the progeny of these. Every cell, whatever its minuteness, if its interior can be discerned, is found filled with the foundations of new cells, into which its nucleus has been resolved. Together with a doubling of the number of the cells, there occurs also a diminution of their size. The cells are at first elliptical, and become globular.

The above mode of augmentation, namely the origin of cells in cells, appears by no means to be limited to the period in question. Thus it is very common to meet with several varieties of epithelium-cells in the oviduct, including those which carry cilia, filled with cells; but the whole embryo at a subsequent period is composed of cells filled with the foundations of other cells.

In the second series of these researches, it was shown that the mulberry-like object above mentioned, is found to contain a cell larger than the rest, elliptical in form, and having in its centre a thick-walled hollow sphere, which is the nucleus of this cell. It was further shown that this nucleus is the rudimental embryo. From what has been just stated, it appears, that the same process, by which a nucleus in one instance transforms itself into the embryo, is in operation in another instance, where the product does not extend beyond the interior of a minute and transitory cell. Making allowance, indeed, for a difference in form and size, the description given of the one might be applied to the other. It was shown in the second series, that in the production of the embryo out of a nucleus, layer after layer of cells come into view in the interior, while layers previously formed are pushed further out; each of the layers being so distinctly circumscribed as to appear almost membranous at its surface. The same membranous appearance presents itself at the surface of the several layers of a nucleus in many situations. Farther, in the formation of the embryo, a pellucid centre is the point around which new layers of cells continually come into view; a centre corresponding to that giving origin to similar appearances in every nucleus described in the present memoir. It was shown that in the embryo this mysterious centre is present until it has assumed the form of the cavity, including the sinus rhomboidalis, in the central portion of the nervous system.

The process above described as giving origin to the new being in the mammiferous ovum, is no doubt universal. The author thinks that there is evidence of its occurrence in the ova of batrachian Reptiles, some osseous Fishes, and certain of the Mollusca; though the explanation given of these has been of a very different character. It has hitherto been usual to regard the round white spot, or cicatricula, on the yelk of the bird's laid egg, as an altered state of the discus vitellinus in the unfecundated ovarian ovum. So far from thinking that such is the case, the author believes the whole substance of the cicatricula in the laid egg to have its origin within the germinal vesicle, in the same manner as in the ovum of Mammalia.

There is no fixed relation between the degree of development of ova, and their size, locality, or age. The variation with regard to size is referable chiefly to a difference in the quantity of fluid imbibed in different instances by the incipient chorion. Vesicles filled with transparent fluid are frequently met with in the Fallopian tube, very much resembling the thick transparent membrane of the ovarian ovum. These vesicles are probably unimpregnated ova, in the course of being absorbed. The so-called "yelk" in the more or less mature ovarian ovum, consists of nuclei in the transition state and exhibiting the compound structure above described. The mass of these becomes circumscribed by a proper membrane. They and their membrane subsequently disappear by liquefaction, and are succeeded by a new set, arising in the interior, and likewise becoming circumscribed by a proper membrane, and so on. This explains why some observers have never seen a membrane in this situation. After the fecundation of the ovum, the cells of the tunica granulosa, that is, part of the so-called "disc," are found to have become club-shaped, greatly elongated, filled in some instances with cells, and connected with the thick transparent membrane by their pointed extremities alone.

That the thin membrane described by the author in his second series as rising from the thick transparent membrane in the Fallopian tube, and imbibing fluid, is really the incipient chorion, was then shown by tracing it from stage to stage, up to the period when villi form upon it. There remained, however, two questions undecided; viz., whether the chorion is formed of cells, and if so, whether the cells are those of the so-called "disc," brought by the ovum from the ovary. The author now states that the chorion is formed of cells, which gradually collect around the thick transparent membrane, and coalesce; and that the cells in question are *not* those of the "disc" brought with the ovum from the ovary. The cells which give origin to the chorion are intended to be more particularly described in a future paper.

The existing view, namely, that a nucleus, when it leaves the membrane of its cell, simply disappears by liquefaction, is inapplicable to any nucleus observed in the course of these investigations. The nucleus resolves itself into incipient cells in the manner above described. In tracing this process, it appears that the nucleus, and especially its central pellucid cavity, is the seat of changes which were not to have been expected from the recently advanced doctrine, that the disappearing nucleus has performed its entire office by giving origin at its surface to the membrane of a single cell. It is the mysterious centre of a nucleus which is the point of fecundation; and the place of origin of two cells constituting the foundation of the new being. The germinal vesicle, as already stated, is the parent cell, which, having given origin to two cells, disappears, each of its successors giving origin to other two, and so on. Perpetuation, however, at this period, consists, not merely in the origin of cells in cells, but in the origin of cells in the pellucid central part of what had been the nucleus of cells.

The author shows that neither the germinal vesicle, nor the pellucid object in the epithelium-cell, is a cytoblast. He suggests, that the cells into which, according to his observations, the nucleus becomes resolved, may enter into the formation of secondary deposits —for instance, spiral fibres; and that they may contribute to the thickening which takes place, in some instances, in the cell-membrane.

The germ of certain plants passes through states so much resembling those occurring in the germ of mammiferous animals, that it is not easy to consider them as resulting either from a different fundamental form, or from a process of development which even in its details is not the same as what has been above described; the fundamental form in question in Mammalia—and therefore it may be presumed of Man himself—being that which is permanent in the simplest plants,—the single isolated cell.

A paper was also read, entitled "On the Odour accompanying Electricity, and on the probability of its dependence on the presence of a new substance;" by C. F. Schœnbein, Professor of Chemistry, Bâle, communicated in a letter to Michael Faraday, Esq., D.C.L., F.R.S., &c.

The author's attention having been long directed to the remarkable fact, that odour, resembling that of phosphorus, is given off during the escape of positive electricity from the point of a conductor into air; and is likewise perceptible when lightning has struck any object, and also when water is electrolyzed, he has investigated the circumstances attending these phenomena; and the results he has obtained will, he expects, afford a clue to the discovery of their cause.

The odour which accompanies the electrolyzation of water, he observes, is only disengaged at the positive electrode. He also finds that the odoriferous principle can be preserved in well-closed glass bottles for any length of time. The only metals which yield this odour are gold and platina; but dilute sulphuric, phosphoric, and nitric acids, and from aqueous solutions of several of the salts, also disengage it. Raising the temperature of the fluid to the boiling point prevents the odour from arising; and the addition of comparatively small quantities of powdered charcoal, iron, zinc, tin, lead, antimony, bismuth or arsenic, or of a few drops of mercury, to the odorous principle contained in a bottle, immediately destroys the smell; and the same happens when platina or gold, heated red hot, is introduced into the vessel containing that volatile substance.

May 14, 1840.

MAJOR EDWARD SABINE, R.A. V.P., in the Chair.

A paper was read, entitled, "Tables of the Variation, through a cycle of nine years, of the mean height of the Barometer, mean Temperature, and depth of Rain, as connected with the prevailing

Winds, influenced in their direction by the occurrence of the Lunar Apsides, with some concluding observations on the result." By Luke Howard, Esq., F.R.S., &c.

From the Tables here given, the author draws the following conclusions :—

1. The barometer is higher under the lunar apogee, than under the perigee ; the mean height in the former case being 29·84517, and in the latter, 29·75542.

2. The mean temperature is lower under the apogee than under the perigee; that of the former being 48°·7126, and of the latter, 49°·0356. The mean of the whole year was 48°·7126.

3. The rain of the weeks following the apsis exceeds that under the perigee; but with two striking exceptions in the annual result of nine years, the one in the wettest, and the other in the driest year of the cycle.

With regard to the winds, the author remarks that those from the north, north-east, and east, prevailed under the apogee on 38 days, under the perigee on 21 days; and those from the south, south-west, and west, prevailed under the apogee on 20 days, under the perigee on 38 days.

It appears, therefore, that in the climate of London, the moon in her perigee brings over us the southern atmosphere, which tends to lower the density and raise the temperature of the air, occasioning also a larger precipitation of rain. In the apogee, on the contrary, there is a freer influx of air from the northward, a higher barometer, a lower temperature, and less rain ; subject, however, to a large addition of rain under this apsis twice in a cycle of nine years, at the times when also the extremes of wet and dry take place on the whole amount of the year.

A paper was also read entitled, "Experimental Researches into the strength of Pillars of Cast Iron, and other materials." By Eaton Hodgkinson, Esq. Communicated by Peter Barlow, Esq., F.R.S., &c.

The author finds that in all long pillars of the same dimensions, the resistance to crushing by flexure is about three times greater when the ends of the pillars are flat, than when they are rounded. A long uniform cast-iron pillar, with its ends firmly fixed, whether by means of disks or otherwise, has the same power to resist breaking as a pillar of the same diameter, and half the length, with the ends rounded, or turned so that the force would pass through the axis. The strength of a pillar with one end round and the other flat, is the arithmetical mean between that of a pillar of the same dimensions with both ends round, and one with both ends flat. Some additional strength is given to a pillar by enlarging its diameter in the middle part.

The author next investigated the strength of long cast-iron pillars with relation to their diameter and length. He concludes that the index of the power of the diameter, to which the strength is proportional, is 3·736. He then proceeds to determine, by a comparison of experimental results, the inverse power of the length to which the strength of the pillar is proportional. The highest value of this power is 1·914, the lowest, 1·537, the mean of all the comparisons, 1·7117. He thus deduces, first, approximate empirical formulæ for the breaking weight of solid pillars, and then proceeds to deduce more correct methods of determining their strength.

Experiments on hollow pillars of cast iron are then described, and formulæ representing the strength of such pillars are deduced from these experiments.

After giving some results of experiments still in progress for determining the power of cast-iron pillars to resist long-continued pressure, the author proceeds to determine from his experiments the strength of pillars of wrought iron and timber, as dependent on their dimensions. The conclusion for wrought iron is, that the strength varies inversely as the square of the pillar's length, and directly as the power 3·75 of its diameter, the latter being nearly identical with the result obtained for cast iron; for timber, the strength varies nearly as the 4th power of the side of the square forming the section of the pillar. Experiments for determining the relation of the strength to the length in pillars of timber, were not instituted, as, from the great flexure of the material, it was considered that no very satisfactory conclusions on this point could be derived experimentally.

In conclusion, the author gives the relative strengths of long pillars of cast iron, wrought iron, steel, and timber.